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(54) LIGHT EMITTING DIODE LIGHT SOURCE

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(58) **Field of Classification Search**
CPC F21V 29/00
See application file for complete search history.

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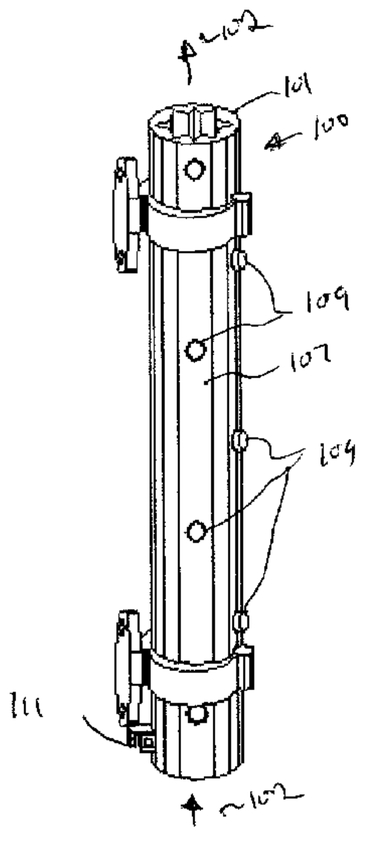
(57) **ABSTRACT**

A light source that utilizes light emitting diodes that emit white light is disclosed. The diodes are mounted on an elongate member having at least two surfaces upon which the light emitting diodes are mounted. The elongate member is thermally conductive and is utilized to cool the light emitting diodes. In the illustrative embodiment, the elongate member is a tubular member through which a heat transfer medium flows.

51 Claims, 3 Drawing Sheets



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Transcript of Videotaped Deposition of A. Brent York, Dec. 1, 2017. *OptoLum, Inc.* vs. *Cree, Inc.*, C.A. No. 1:17-cv-00687, United States District Court for the Middle District of North Carolina, 77 pages. (Exhibit B for Opposition of OptoLum, Inc. to Cree, Inc.'s Motion for Summary Judgment for Invalidity of U.S. Pat. No. 7,242,038 under 35 U.S.C. §101, or in the Alternative, 35 U.S.C. §112, dated Feb. 5, 2018.)
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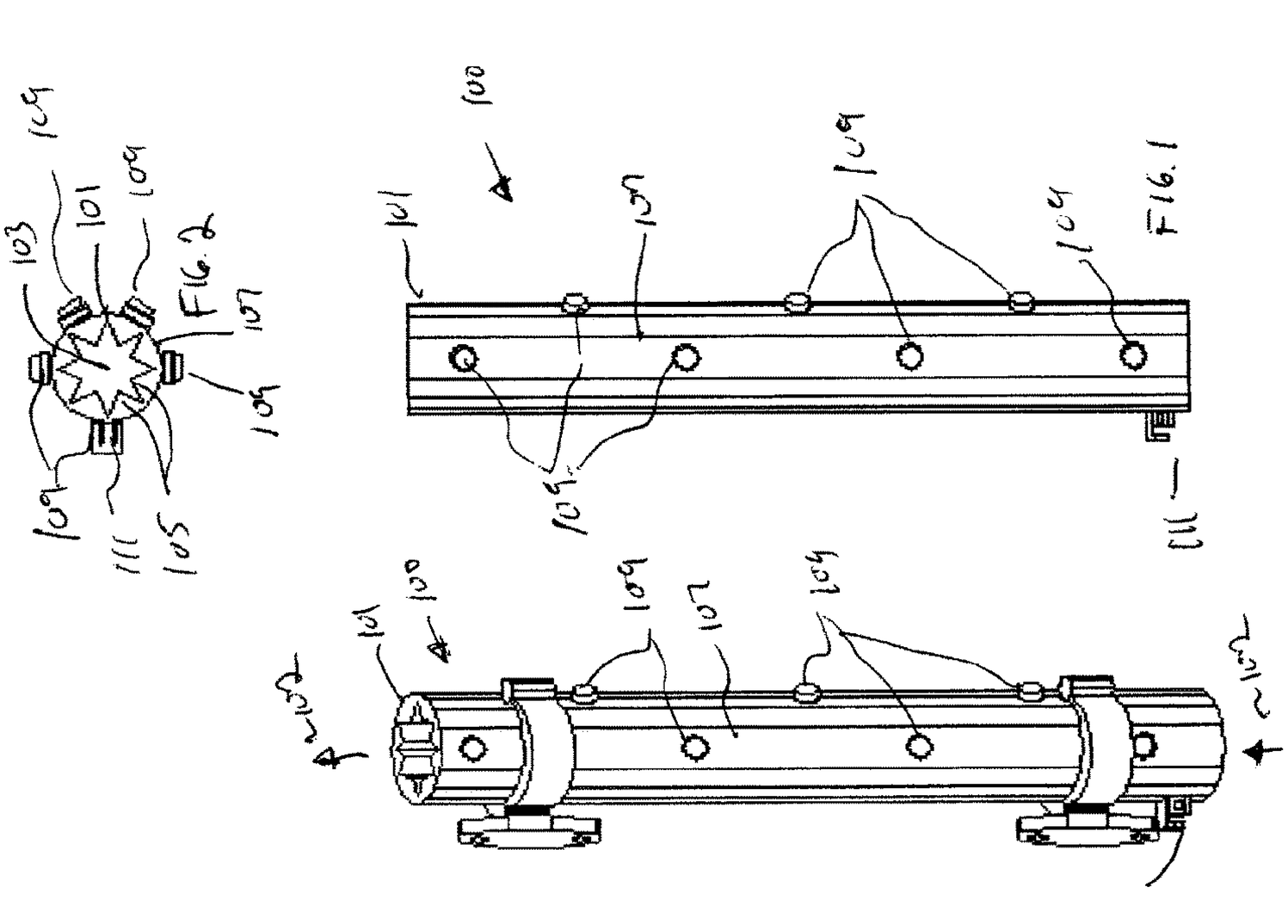

FIG. 1

FIG. 2

FIG. 3

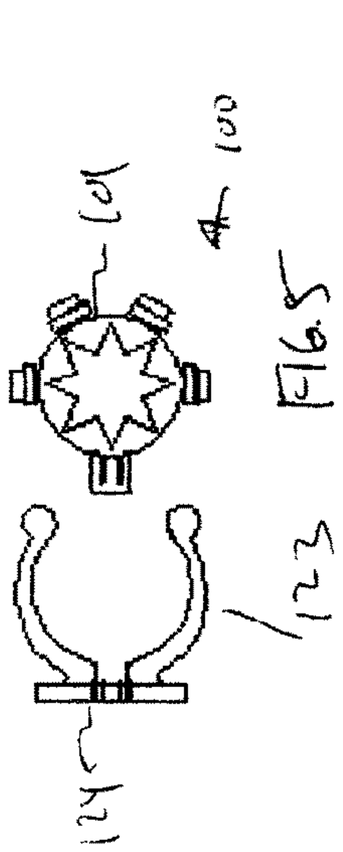

FIG 5

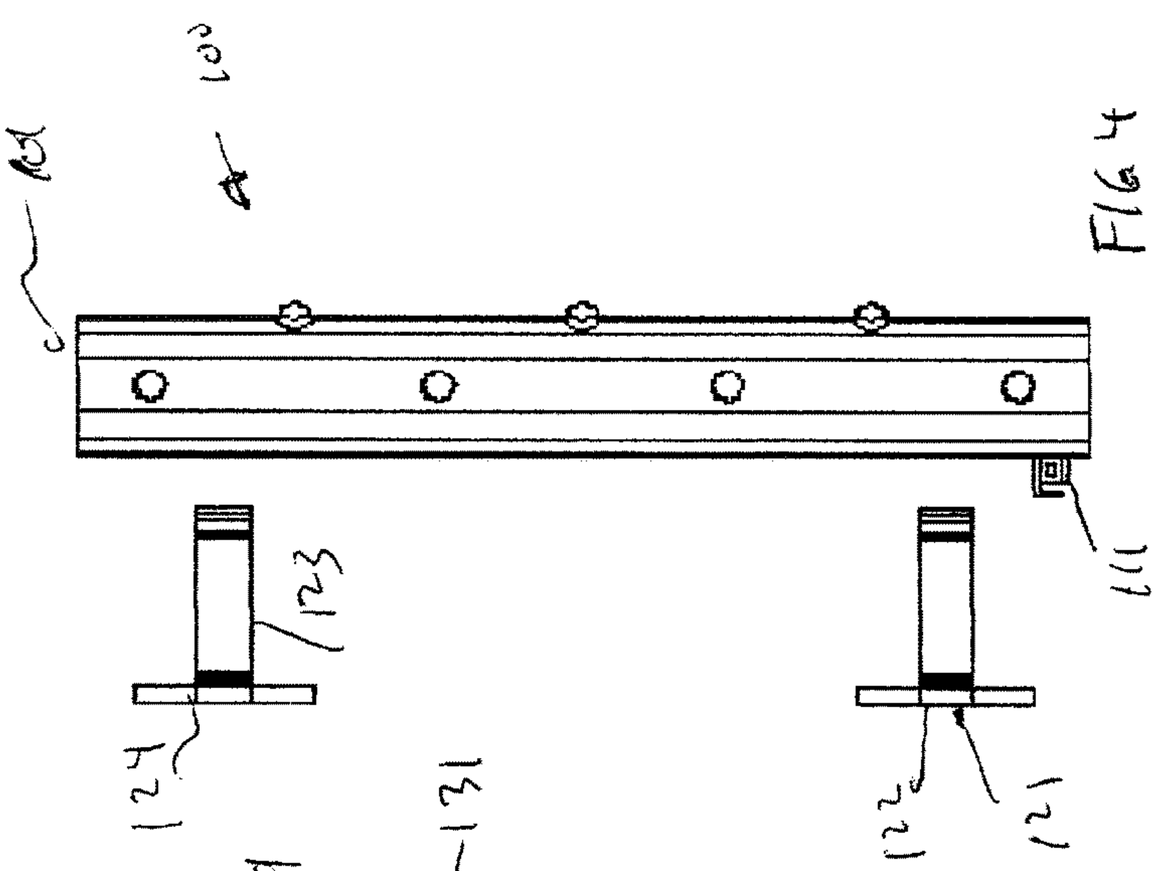

FIG 4

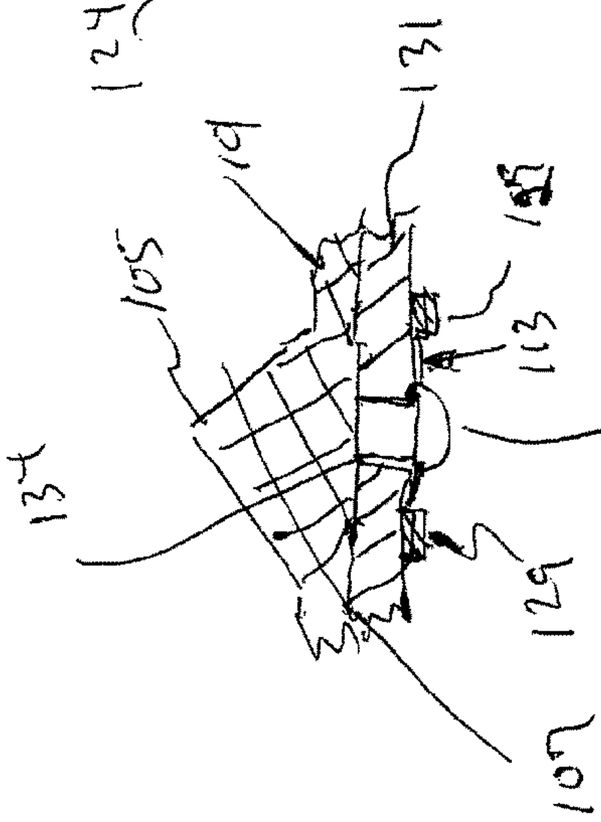

FIG. 6

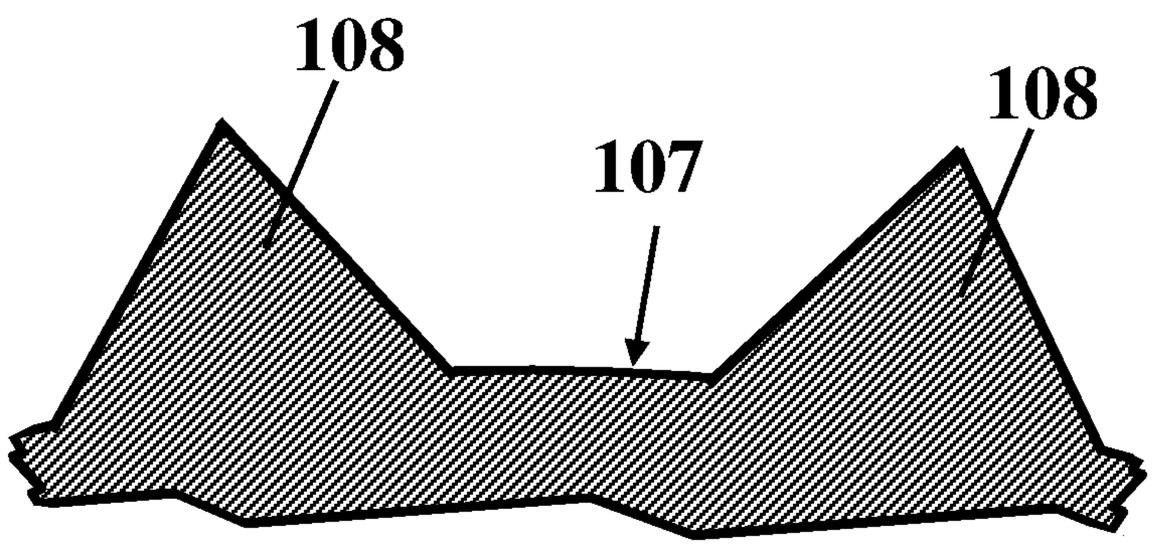

FIG. 7

LIGHT EMITTING DIODE LIGHT SOURCE

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

RELATED APPLICATIONS

More than one reissue application has been filed for the reissue of U.S. Pat. No. 6,573,536. The reissue applications are application Ser. No. 15/423,898 filed Feb. 3, 2017, which is the present application, and application Ser. No. 15/424,517 filed Feb. 3, 2017, which is a continuation reissue of the present application.

This application is a reissue application of U.S. Pat. No. 6,573,536, which issued on Jun. 3, 2003.

FIELD OF THE INVENTION

This invention pertains to lighting sources, in general, and to a lighting source that utilizes Light Emitting Diodes (LED's), in particular.

BACKGROUND OF THE INVENTION

LED's have many advantages as light sources. However, in the past LED's have found application only as specialized light sources such as for vehicle brake lights, and other vehicle related lighting, and recently as flashlights. In these prior applications, the LED's are typically mounted in a planar fashion in a single plane that is disposed so as to be perpendicular to the viewing area. Typically the LED planar array is not used to provide illumination, but to provide signaling.

Recent attempts to provide LED light sources as sources of illumination have been few, and generally unsatisfactory from a general lighting standpoint.

It is highly desirable to provide a light source utilizing LED's that provides sufficient light output so as to be used as a general lighting source rather than as a signaling source.

One problem that has limited the use of LED's to specialty signaling and limited general illumination sources is that LED's typically generate significant amounts of heat. The heat is such that unless the heat is dissipated, the LED internal temperature will rise causing degradation or destruction of the LED.

It is therefore further desirable to provide an LED light source that efficiently conducts heat away from the LED's.

SUMMARY OF THE INVENTION

In accordance with the principles of the invention, an improved light source is provided. The light source includes an elongate thermally conductive member having an outer surface. A plurality of light emitting diodes is carried on the elongate member outer surface. At least some of the light emitting diodes are disposed in a first plane and others of said light emitting diodes are disposed in a second plane not coextensive with the first plane. Electrical conductors are carried by the elongate thermally conductive member and are connected to the plurality of light emitting diodes to supply electrical power thereto. The elongate thermally conductive member conducts heat away from the light emitting diodes.

In accordance with one aspect of the invention, an illustrative embodiment of the invention utilizes light emitting diodes that emit white light. However, other embodiments of the invention may utilize light emitting diodes that are of different colors to produce monochromatic light or the colors may be chosen to produce white light or other colors.

In accordance with another aspect of the invention the elongate thermally conductive member transfers heat from the light emitting diodes to a medium within said elongate thermally conductive member. In the illustrative embodiment of the invention, the medium is air.

In accordance with another aspect of the invention, the elongate thermally conductive member has one or more fins to enhance heat transfer to the medium.

In accordance with another aspect of the invention the elongate thermally conductive member comprises a tube. In one embodiment of the invention, the tube has a cross-section in the shape of a polygon. In another embodiment of the invention, the tube has a cross-section having flat portions.

In accordance with another embodiment of the invention, the elongate thermally conductive member comprises a channel.

In accordance with the principles of the invention, the elongate thermally conductive member may comprise an extrusion, and the extrusion can be highly thermally conductive material such as aluminum.

In one preferred embodiment of the invention the elongate thermally conductive member is a tubular member. The tubular member has a polygon cross-section. However, other embodiments my have a tubular member of triangular cross-section.

In one embodiment of the invention, a flexible circuit is carried on a surface of said elongate thermally conductive member; the flexible circuit includes the electrical conductors.

In another aspect of the invention, the flexible circuit comprises a plurality of apertures for receiving said plurality of light emitting diodes. Each of the light emitting diodes is disposed in a corresponding one of the apertures and affixed in thermally conductive contact with said elongate thermally conductive member.

The elongate thermally conductive member includes a thermal transfer media disposed therein in a flow channel.

At least one clip for mounting the elongate thermally conductive member in a fixture may be included.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be better understood from a reading of the following detailed description of a preferred embodiment of the invention taken in conjunction with the drawing figures, in which like reference indications identify like elements, and in which:

FIG. **1** is a planar side view of a light source in accordance with the principles of the invention;

FIG. **2** is a top planar view of the light source of FIG. **1**;

FIG. **3** is a perspective view of the light source of FIG. **1** with mounting clips;

FIG. **4** is a planar side view of the light source of FIG. **3** showing mounting clips separated from the light source;

FIG. **5** is a top view of the light source and mounting clips of FIG. **4**; and

FIG. **6** is a partial cross-section of the light source of FIG. **1**.

FIG. 7 is a cross-sectional view of a portion of an elongate heat sink with fins on an outer surface of the heat sink in accordance with some embodiments.

DETAILED DESCRIPTION

A light source in accordance with the principles of the invention may be used as a decorative lighting element or may be utilized as a general illumination device. As shown in FIG. **1**, a light source **100** in accordance with the invention includes an elongate thermally conductive member or heat sink **101**. Elongate heat sink **101** is formed of a material that provides excellent thermal conductivity. Elongate heat sink **101** in the illustrative embodiment of the invention is a tubular aluminum extrusion. To improve the heat dissipative properties of light source **100**, elongate heat sink **101** is configured to provide convective heat dissipation and cooling. As more clearly seen in FIG. **2**, tubular heat sink **101** is hollow and has an interior cavity **103** that includes one or more heat dissipating fins **105**. Fins **105** are shown as being triangular in shape, but may take on other shapes. Fins **105** are integrally formed on the interior of elongate heat sink **101**. In the illustrative embodiment convective cooling is provided by movement of a medium **102** through elongate heat sink **101**. The medium utilized in the illustrative embodiment is air, but may in some applications be a fluid other than air to provide for greater heat dissipation and cooling.

The exterior surface **107** of elongate heat sink **101** has a plurality of Light Emitting Diodes **109** disposed thereon. Each LED **109** in the illustrative embodiment comprises a white light emitting LED of a type that provides a high light output. Each LED **109** also generates significant amount of heat that must be dissipated to avoid thermal destruction of the LED. By combining a plurality of LEDs **109** on elongate heat sink **101**, a high light output light source that may be used for general lighting is provided.

Conductive paths **129** are provided to connect LEDs **109** to an electrical connector **111**. The conductive paths may be disposed on an electrically insulating layer **131** or layers disposed on exterior surface **107**. In the illustrative embodiment shown in the drawing figures, the conductive paths and insulating layer are provided by means of one or more flexible printed circuits **113** that are permanently disposed on surface **107**. As more easily seen in FIG. **6**, printed circuit **113** includes an electrically insulating layer **131** that carries conductive paths **129**. As will be appreciated by those skilled in the art, other means of providing the electrically conductive paths on the

Flexible printed circuit **113** has LED's **109** mounted to it in a variety of orientations ranging from 360 degrees to 180 degrees and possibly others depending on the application. Electrical connector **111** is disposed at one end of printed circuit **113**. Connector **113** is coupleable to a separate power supply to receive electrical current. Flexible printed circuit **113**, in the illustrative embodiment is coated with a non-electrically conductive epoxy that may be infused with optically reflective materials. Flexible printed circuit **113** is adhered to the tube **101** with a heat conducting epoxy to aid in the transmission of the heat from LEDs **109** to tube **101**. Flexible printed circuit **113** has mounting holes **134** for receiving LEDs **109** such that the backs of LEDs **109** are in thermal contact with the tube surface **107**.

Tubular heat sink **101** in the illustrative embodiment is formed in the shape of a polygon and may have any number of sides. Although tubular heat sink **101** in the illustrative embodiment is extruded aluminum, tubular heat sink **101** may comprise other thermal conductive material. Fins **105** may vary in number and location depending on particular LED layouts and wattage. In some instances, fins *108* may be added to the exterior surface of tubular heat sink **101** (*see, e.g., FIG. 7*). In addition, apertures may be added to the tubular heat sink to enhance heat flow.

Light source **100** is mounted into a fixture and retained in position by mounting clips **121**, **123** as most clearly seen in FIGS. **3**, **4**, and **5**. Each of the clips is shaped so as to engage and retain light source **100**. Each clip is affixed on one surface **122**, **124** to a light fixture.

Although light source **100** is shown as comprising an elongate tubular heat sink, other extruded elongate members may be used such as channels.

In the illustrative embodiment shown, convection cooling by flow of air through tubular heat sink **101** is utilized such that cool or unheated air enters tubular heat sink **101** at its lower end and exits from the upper end as heated air. In higher wattage light sources, rather than utilizing air as the cooling medium, other fluids may be utilized. In particular, convective heat pumping may be used to remove heat from the interior of the heat sink.

In one particularly advantageous embodiment of the invention, the light source of the invention is configured to replace compact fluorescent lighting in decorative applications.

As will be appreciated by those skilled in the art, the principles of the invention are not limited to the use of light emitting diodes that emit white light. Different colored light emitting diodes may be used to produce monochromatic light or to produce light that is the combination of different colors.

Although the invention has been described in terms of illustrative embodiments, it is not intended that the invention be limited to the illustrative embodiments shown and described. It will be apparent to those skilled in the art that various changes and modifications may be made to the embodiments shown and described without departing from the spirit or scope of the invention. It is intended that the invention be limited only by the claims appended hereto.

What is claimed is:

1. A light source comprising:

an elongate thermally conductive member having an outer surface, *a first end, and a second end*;

[at least one**]** *a plurality of* light emitting diodes carried on said elongate member outer surface;

one or more electrical conductors carried by said elongate thermally conductive member and connected to said **[**at least one**]** *plurality of* light emitting diodes to supply electrical power thereto; **[**and**]**

said elongate thermally conductive member being configured to conduct heat away from said **[**at least one light emitting diode**]** *plurality of light emitting diodes* to fluid contained by said elongate thermally conductive member;

wherein a back of each of said plurality of light emitting diodes is in thermal contact with a corresponding underlying portion of said elongate member outer surface;

wherein said elongate thermally conductive member comprises:

at least one opening at the first end that facilitates entry of fluid into said elongate thermally conductive member; and

at least one opening at the second end that facilitates convective movement of heated fluid out of said elongate thermally conductive member; and

a plurality of exterior fins added to said elongate member outer surface to conduct heat to fluid surrounding said plurality of exterior fins thereby facilitating convective heat dissipation.

2. A light source comprising:

an elongate thermally conductive member having an outer surface, *a first end, and a second end*;

a plurality of light emitting diodes carried on said elongate member outer surface, at least some of said light emitting diodes being disposed in a first plane and others of said light emitting diodes being disposed in a second plane not coextensive with said first plane;

electrical conductors carried by said elongate thermally conductive member and connected to said plurality of light emitting diodes to supply electrical power thereto; **[**and**]**

said elongate thermally conductive member being configured to conduct heat away from said *plurality of* light emitting diodes to fluid contained by said elongate thermally conductive member;

wherein a back of each of said plurality of light emitting diodes is in thermal contact with a corresponding underlying portion of said elongate member outer surface;

wherein said elongate thermally conductive member comprises:

at least one opening at the first end that facilitates entry of fluid into said elongate thermally conductive member; and

at least one opening at the second end that facilitates convective movement of heated fluid out of said elongate thermally conductive member; and

a plurality of exterior fins added to said elongate member outer surface to conduct heat to fluid surrounding said plurality of exterior fins thereby facilitating convective heat dissipation.

3. A light source in accordance with claim **2**, wherein: each of said *plurality of* light emitting diodes emits white light.

4. A light source in accordance with claim **2**, wherein: said fluid comprises air.

[5. A light source in accordance with claim **4**, wherein: said elongate thermally conductive member comprises one or more heat dissipation protrusions.**]**

6. A light source in accordance with claim **2**, wherein: said elongate thermally conductive member comprises a tube.

7. A light source in accordance with claim **6**, wherein: said tube has a cross-section in the shape of a polygon.

8. A light source in accordance with claim **6**, wherein: said tube has a cross-section having flat portions.

9. A light source in accordance with claim **2**, wherein: said elongate thermally conductive member comprises a channel.

10. A light source in accordance with claim **2**, wherein: said elongate thermally conductive member comprises an extrusion.

11. A light source in accordance with claim **10**, wherein: said extrusion is an aluminum extrusion.

12. A light source in accordance with claim **11**, wherein: said elongate thermally conductive member is a tubular member.

13. A light source in accordance with claim **12**, wherein: said tubular member has a polygon cross-section.

14. A light source in accordance with claim **12**, wherein: said tubular member has a triangular cross-section.

15. A light source in accordance with claim **2**, *further* comprising: a flexible circuit carried on a surface of said elongate thermally conductive member, said flexible circuit comprising said electrical conductors.

16. A light source in accordance with claim **15**, wherein: said flexible circuit comprises a plurality of apertures for receiving said plurality of light emitting diodes.

17. A light source in accordance with claim **16**, wherein: each of said light emitting diodes is disposed in a corresponding one of said apertures and affixed in thermally conductive contact with said elongate thermally conductive member.

[18. A light source in accordance with claim **2**, wherein: a thermal transfer media disposed therein.**]**

19. A light source in accordance with claim **[18]** *2*, wherein: said elongate thermally conductive member comprises a flow channel for said **[**thermal transfer media**]** *fluid*.

20. A light source in accordance with claim **2**, *further* comprising: at least one clip for mounting said elongate thermally conductive member in a fixture.

21. A light source in accordance with claim **2**, *further* comprising: an electrically insulating layer disposed on said elongate thermally conductive member outer surface and carrying said electrical conductors thereon.

22. A light source in accordance with claim **21**, wherein: said electrically insulating layer comprises a plurality of apertures, each aperture receiving one of said light emitting diodes; and each light emitting diode of said plurality of light emitting diodes being mounted in a corresponding one of said apertures **[**and in thermally conductive contact with said elongate thermally conductive member**]**.

23. A light source in accordance with claim **22**, wherein: each of said *plurality of* light emitting diodes emits white light.

24. A light source in accordance with claim 2, wherein a longitudinal axis of each of said plurality of exterior fins is substantially aligned with a longitudinal axis of said elongate thermally conductive member.

25. A light source in accordance with claim 2, wherein the elongate thermally conductive member defines an interior cavity, and wherein the elongate thermally conductive member further comprises a plurality of interior fins extending into the interior cavity.

26. The light source in accordance with claim 25, wherein the plurality of interior fins comprises integral fins.

27. A light source in accordance with claim 25, wherein each of said plurality of interior fins has a longitudinal axis substantially aligned with a longitudinal axis of said elongate thermally conductive member.

28. A light source in accordance with claim 2, wherein said elongate thermally conductive member further comprises one or more apertures between the first end and the second end enhancing fluid flow through said elongate thermally conductive member.

29. A light source in accordance with claim 2, wherein said plurality of light emitting diodes further comprises a first plurality of light emitting diodes disposed in a third plane not coextensive with said first plane or said second plane.

30. A light source in accordance with claim 2, wherein said plurality of light emitting diodes are evenly distributed along a length of said elongate thermally conductive member for efficient heat dissipation.

31. A light source in accordance with claim 15, wherein said back of each of said plurality of light emitting diodes

maintains said thermal contact with said elongate member outer surface through said flexible circuit.

32. A light source in accordance with claim 2, wherein said back of each of said plurality of light emitting diodes maintains said thermal contact with said elongate member outer surface through a printed circuit.

33. A light source in accordance with claim 2, wherein said plurality of light emitting diodes are mounted in orientations spanning a range of 180 degrees to 360 degrees.

34. A light source in accordance with claim 1, wherein each of said plurality of exterior fins has a longitudinal axis substantially aligned with a longitudinal axis of said elongate thermally conductive member.

35. A light source in accordance with claim 1, wherein the elongate thermally conductive member defines an interior cavity, and wherein the elongate thermally conductive member further comprises a plurality of interior fins extending into the interior cavity.

36. The light source in accordance with claim 35, wherein the plurality of interior fins comprises integral fins.

37. A light source in accordance with claim 35, wherein each of said plurality of interior fins has a longitudinal axis substantially aligned with a longitudinal axis said elongate thermally conductive member.

38. A light source in accordance with claim 1, wherein: said elongate thermally conductive member comprises a flow channel for said fluid.

39. A light source in accordance with claim 1, wherein said elongate thermally conductive member further comprises one or more apertures between the first end and the second end enhancing fluid flow through said elongate thermally conductive member.

40. A light source in accordance with claim 1, wherein: each of said plurality of light emitting diodes emits white light.

41. A light source in accordance with claim 1, wherein said plurality of light emitting diodes comprise a plurality of light emitting diodes disposed in a single plane.

42. A light source in accordance with claim 1, wherein said plurality of light emitting diodes are mounted in orientations spanning a range of 180 degrees to 360 degrees.

43. A light source in accordance with claim 1, wherein said plurality of light emitting diodes are evenly distributed along a length of said elongate thermally conductive member for efficient heat dissipation.

44. A light source in accordance with claim 1, wherein a cross-section of said elongate thermally conductive member comprises flat portions.

45. A light source in accordance with claim 1, wherein said back of each of said plurality of light emitting diodes maintains said thermally conductive contact with said elongate member outer surface through a printed circuit.

46. A light source in accordance with claim 1, further comprising: an electrically insulating layer disposed on said elongate thermally conductive member outer surface and carrying said electrical conductors thereon.

47. A light source in accordance with claim 1, wherein said plurality of light emitting diodes emits colored light.

48. A light source in accordance with claim 47, wherein said light source produces white light.

49. A light source in accordance with claim 1, wherein said light source is configured for general illumination.

50. A light source in accordance with claim 1, wherein said elongate thermally conductive member is a single integral piece.

51. A light source in accordance with claim 2, wherein said plurality of light emitting diodes emits colored light.

52. A light source in accordance with claim 51, wherein said light source produces white light.

53. A light source in accordance with claim 2, wherein said elongate thermally conductive member is a single integral piece.

* * * * *